Tree Diversity and the Changes of Wood Utilization of Tropical Rain Forest in Borneo

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Introduction

The lowland tropical rain forests of Borneo are characterized by high tree species diversity and the stratification of multiple foliage layers, which exceed 60 meter in height with emergent trees. Above-ground biomass is also high. The lowland forests of Borneo are characterized by many Dipterocarpaceae species and called a mixed dipterocarp forest. The diversity and stand structure of the dipterocarp forest relate with environmental conditions such as soil nutrient, topography and altitude.

Humans use forest products from tropical rain forest as wood in terms of biomass stock, and as tropical fruits and medicinal ingredients in terms of species diversity. With regard to wood utilization, the amount of harvests and the species that are harvested have changed with human activity. As a recent trend, deforested area is increasing and the depletion of the wood resource is expected to rise from increasing demand for resources. In the project "Sustainability and biodiversity assessment on forest-utilization options" by RIHN, we began our research in Deramakot Forest Reserve in Sabah, Malaysia, which introduced low impact selective-logging (Reduced Impact Logging, RIL) method. The policy and aim of forest management in Deramakot Forest Reserve are to establish the harmony between biodiversity maintenance and the sustainable utilization of forest products with the employment of an ecological approach. A strict forest management has been applied to Deramakot Forest Reserve (Lagan et al 2007). Thus, this site is a good model for the research project focused on the relationship between forest ecosystem and historical background of human forest utilization. Here, we report how harvested species changed with the introduction of heavy machinery and how the change was related with the density of wood in the lowland dipterocarp forest.

Method

The study site

The study site (5˚22'N, 117˚25' E, approximately 300 m asl) is located in a lowland forest of the Deramakot Forest Reserve (DFR) in Sabah, Malaysian Borneo. Forests in DFR had been selectively logged in the 1970s (Lagan et al. 2007). DFR was logged again with RIL from the 1990s in contrast with the surrounding areas which were harvested by a more destructive, conventional logging method. Thus, the forests in DFR can be divided into the following three types as the old-growth forests in DFR without any logging records after the 1970s logging, the forests logged with RIL after 1996 in addition to the conventional logging prior to 1996, and the forests continuously logged with the conventional method (Aiba et al. in Chapter 3).

Diversity of wood density

As for the dipterocarp trees, a commercial classification according to the specific gravity of wood is available based on vernacular names (Wood and Meijer 1964). In Sabah, dipterocarp trees were classified as Seraya (including genus *Shorea* and *Parashorea*, approx. 0.50 g cm^{-3} in specific gravity), Selangan Batu (sect. *Shorea* and *Neohopea* of genus *Shorea*, approx. 0.80 g cm^{-3} in specific gravity), Kapur (genus *Dryobalanops*, approx. 0.70 g cm^{-3} in specific gravity), and Keruing (genus *Dipterocarp*, approx. 0.75 g cm^{-3} in specific gravity). We followed the vernacular classification by Wood and Meijer (1964) in our analysis. For the analysis of wood utilisation, and the changes of the frequency distribution of wood density in relation to harvest intensity, data of specific gravity of wood were obtained from Wood and Meijer (1964), Burgess (1966) and Suzuki (1998) (including sapling data), and unpublished data by Seino. We applied those density data to the observed species in Deramakot Forest Reserve in the research plots described by Aiba et al. (in Chapter 3).

Historical background of forestry in Sabah

Historical background of forestry in Sabah was examined from literatures, official reports, and technical documents (Sabah Forestry Department .1989; 2003; Forest Research Institute Malaysia 2001).

Results

Historical background of timber production in Sabah

The first commercial logging in Sabah was started in around 1895 by a UK enterprise, and the Forest Bureau in Sandakan was set up in 1915. Since then, the commercial harvest of forests in Sabah has been developed to a fuller scale. Main mode of the logging at the earliest time was axe cutting of trees and wood transportation was conducted by human power, horse, and rafting. As these methods depended on human power, those trees which were low in specific gravity of wood were preferentially logged due to the limitation of transportation technology and labour. Therefore, harvest was limited to the neighbouring districts of a town and riverside (Sabah Forestry Department 1989). There is a local terminology for this type of logging called “Memingel” in a traditional village in a river bank of Sabah. Memingel is a traditional wood transportation method – the logs cut by an axe on a small scale in upstream forests are naturally transported to the downstream village by floods during a wet season. Illegal encroachments using this method can also occur (Kitayama personal communication).

The amount of harvested wood in Sabah was increased by the major lumber companies especially after the World War II. After the introduction of tractor and mechanical equipments such as trucking, and the establishment of large-scale woodland path and logging road network, a large amount of logs was carried from the forests in central part of Sabah. This was accelerated especially after the

World War II. Moreover, it became comparatively easy to carry trees that were high in specific gravity of wood and a large amount of logs was harvested by improved techniques utilizing chainsaw and motor lorry. The harvest impact and deforestation pressure became higher by increased mechanization with heavier wood increasingly harvested (Sabah Forestry Department 1989; Forest Research Institute Malaysia 2001).

Differences of specific gravity of wood

Fig.1 shows the differences in the frequency distribution of stems for the specific gravity of wood among different logging impacts in Deramakot. The frequency distribution of the specific gravity of wood for the tree species in the natural lowland forest is shown by the normal distribution that has the average value of 0.57 g cm^{-3} in agreement with Turner (2001). Mean specific gravity of individual stems was 0.67 g cm^{-3} in old-growth forest, 0.62 g cm^{-3} in forest harvested by RIL, and 0.49 g cm^{-3} in forest harvested by conventional method, respectively.

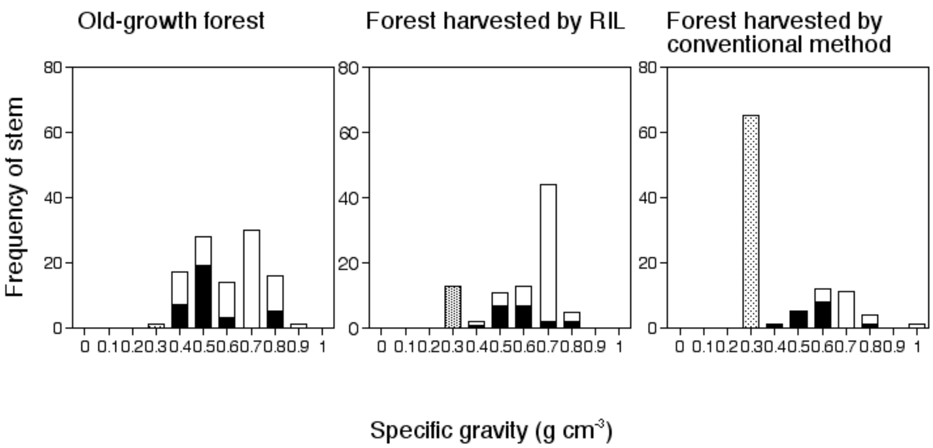

Figure 1. Comparison of the frequency of stems in the classes of the specific gravity of wood among different forest managements in Deramakot Forest Reserve. Closed, shaded, and open bar indicate specific gravity of Dipterocarpaceae, *Macaranga* of Euphorbiaceae, and the other tree species, respectively.

Fig.2 shows the differences of frequency distribution of species number for the specific gravity of wood among different logging impacts. Frequency distribution of the specific gravity of wood was not different among logging impacts (Kolmogorov-Smirnov test, $P > 0.05$). When specific gravity was weighted by species number, mean specific gravity was 0.64 g cm^{-3} in old-growth forest, 0.64 g cm^{-3} in the forest harvested by RIL, and 0.67 g cm^{-3} in the forest harvested by conventional logging method.

Mean specific gravity of the major species of Dipterocarpaceae varies greatly; Seraya group, *Shorea domatiosa* (0.50), *S. macrophylla* (0.50), *S.gibbosa* (0.57), and *S. fallax* (0.56); Kapur, *Dryobalanops lanceolata* (0.69); and Keruing, *Dipterocarps kerri* (0.69 g cm^{-3}, specific gravity). On the other hand, average specific gravity of the pioneer species of genus *Macaranga* (Euphorbiaceae) was low; *Macaranga conifera* (0.40 g cm^{-3}, specific gravity), *M. hypolueca* (0.33), *M. gigantea* (0.36), and *M. pearsonii* (0.39). Logging impact resulted in the increase of the abundance of *Macaranga* trees that are characterized by light wood (approx 0.30 g cm^{-3} in specific gravity) and associated fast growth with their preferential establishment on heavily disturbed area.

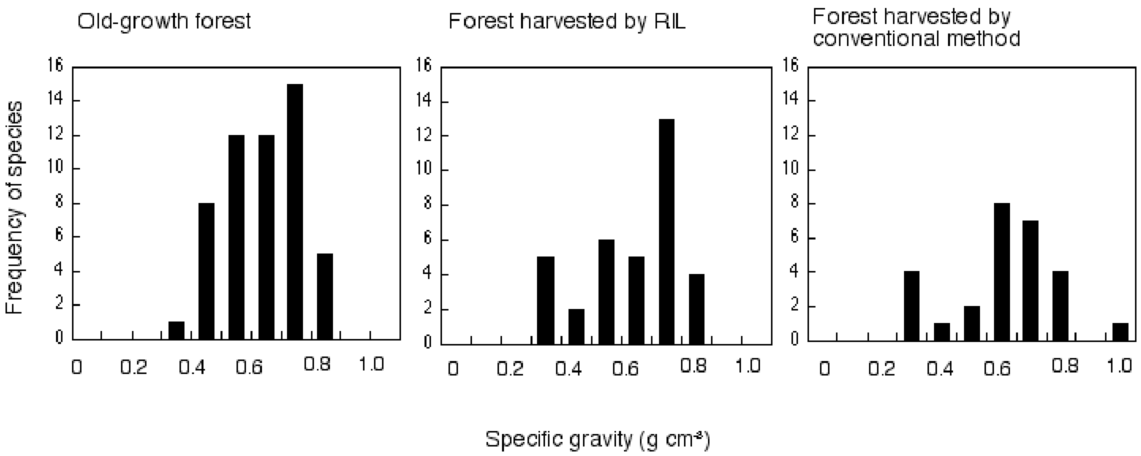

Figure 2. The comparison of the frequency of species in the classes of the specific gravity of wood among different forest managements in Deramakot Forest Reserve.

Discussion

Results from the frequency of stems in the classes of the specific gravity of wood demonstrate the dominance of light wood in the conventionally logged forest primarily due to the dominance of *Macaranga* (Fig. 1). In the old-growth forest, dipterocarp trees of comparatively low specific gravity (light-wood, e.g., Seraya) accounted for roughly 30% of the total basal area, and those of high specific gravity (heavy-wood, e.g., Selangan Batu, Kapur and Keruing) accounted for roughly 10-20% of the total basal area in the Deramakot Forest Reserve. An appropriate logging plan is needed to control the resource depletion of such heavy-wood species. The heavy-wood trees were sparse in their population probably reflecting past harvest and the slow recovery due to the slow growth of heavy-wood species in the forest harvest by the conventional logging. Suzuki (1998) discussed relationship between specific gravity of wood and growth traits. Most of light-wood trees were characterized by fast growth, while heavy-wood trees were characterized by slow growth. Light-wood trees tend to bear a smaller number of vessels with large pore area and heavy-wood trees tend to bear a larger number of vessels with small pore area (Santiago et al. 2004). Santiago et al. (2004) conclude that fast-growing trees needed a large amount of water for photosynthesis and that they sacrificed wood density for hydraulic transportation of water.

Currently, the heavily logged forest outside Deramakot Forest Reserve has the species composition with the dominance of light-wood trees as a result of modern forest practice (Fig. 1). The advancement of the modern technology has lead to the simplification of ecological traits of species such as specific gravity of wood. The usage of Dipterocarpaceae timber is shown in Table 1. The usage is different depending on their wood specific gravity.

The timber with a much greater specific-gravity of wood (heavy wood) such as Borneo ironwood (*Eusideroxylon zwageri*) of Lauraceae is also available and it is used for different purposes such as pillar and roofing tile. On the other hand, the timber with much lighter gravities has not traditionally been used. For instance, the timber of *Macaranga* has no commercial importance. However, the light-wood species that have not been used commercially in the past are being utilized in recent years. The commercial utilization of a pioneer tree *Neolmarckia cadamba* of Rubiaceae is one of such examples (Sabah Forestry Department 2003). *Neolmarckia cadamba* has a light specific gravity and is used for packing materials/boxes. Human exploitation nearly depleted the timber resources of moderate and heavy wood and lead to a diversified use of light wood.

Table 1. Timber use of Dipterocarpaceae common in Sabah.

Type of wood	Specific gravity ($g\ cm^{-3}$)	Purpose	Local classification based on wood
Heavy wood	0.72 – over	Constructional timber Wharf decking Flooring interior Etc.	Keruing Kapur Selangan Batu
Light wood	0.48 – 0.72	Flooring interior Plywood Interior fitting Etc.	Seraya

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